Central Air Conditioner and Heat Pump Life-Cycle Cost Spreadsheet Documentation

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How many Life-Cycle Cost (LCC) spreadsheets are there?

There are currently two LCC spreadsheets; one for central air conditioners (**lcc_cac.xls**) and another for heat pumps (**lcc_hp.xls**). Each spreadsheet allows the user to perform LCC analyses of either split or single package systems. The user can also choose between two sets of manufacturer costs; one based on data submitted by the Air Conditioning & Refrigeration Institute (ARI) and the other based on data developed through a reverse engineering analysis (Rev Eng) conducted by Arthur D. Little, Inc. (ADL).

What do the Life-Cycle Cost (LCC) spreadsheets do?

The LCC spreadsheets perform calculations to determine life-cycle cost and payback periods. The LCC spreadsheets operate in Excel 97 or Excel 7 (Windows 95). The Excel add-on *Crystal Ball* (version 4.0) allows the user to perform uncertainty analysis on key input variables.

What are the Worksheets in the Workbook?

Each LCC spreadsheet or workbook consists of the following worksheets:

LCC (Sample Calc)	contains the input selections and a summary table of energy use, operating costs, LCC and Payback.
LCC (Simulations)	contains the input selections as in the LCC (Sample Calc) sheet. If Crystal Ball is running, the energy, cost, LCC, and payback data are from the current sample. If *Crystal Ball* has finished running, the data are from the final sample.
Engineering (split ARI)	contains the manufacturer costs submitted by ARI for split systems at each efficiency level. Also included are the manufacturer, distributor, and dealer markups, the sales tax, the installation price, and the repair and maintenance costs.
Engineering (split Rev Eng)	contains the same data as **Engineering (split ARI)** with the exception that the manufacturer costs are developed through reverse engineering rather than by ARI.

Engineering (pack ARI)	contains the same data as **Engineering (split ARI)** with the exception that manufacturer costs are for single package rather than split systems.
Engineering (pack Rev Eng)	contains the same data as **Engineering (pack ARI)** with the exception that manufacturer costs are developed through reverse engineering rather than by ARI.
Household Data	for each sample household, contains average and marginal electricity prices, annual space-cooling energy consumption (and space-heating energy consumption for heat pumps), the station (i.e., geographic) location, the year the household was built, and the equipment's age index.
Energy Price	contains projections of future energy prices from various sources.
SEER Dist	contains historical shipment-weighted efficiency data by year; this is used for determining the probable SEER of existing space-conditioning equipment based on age.
HSPF Dist	contains historical shipment-weighted efficiency data by year; this is used for determining the probable HSPF of existing heat pump based on age. (This worksheet is included only in the LCC spreadsheet for heat pumps (**lcc_shp.xls**)).
Seasonal Allocation Factors	contains seasonal (i.e., summer and non-summer) allocation factors of annual cooling (or heating) energy which indicate the fraction used by season. The seasonal allocation factors are based on the age and the geographic location of the household. The factors are used for determining the annual marginal electricity rate. Summer and non-summer allocation factors are multiplied by summer and non-summer marginal rates, respectively, and then summed to arrive at the annual marginal rate.
drate dist	contains data from which an average discount rate and a distribution of discount rates are determined.
Lifetime	contains the survival function for central air conditioners and heat pumps and the average central air conditioner and heat pump lifetime in years.
Setup	this is used as an interface between user inputs and the rest of the worksheets -- do not modify this sheet.

How does the user operate the spreadsheet?

To execute the spreadsheets fully you will need both Microsoft Excel and *Crystal Ball* software. Both applications are commercially available. *Crystal ball* is available at http://www.decisioneering.com.

1. Once you have downloaded the LCC file from the Web, open the file using Excel. At the bottom, click on the tab for sheet **LCC (Sample Calc)** or **LCC (Simulations)**.

2. Use Excel's commands at the top **View/Zoom** to change the size of the display to make it fit your monitor.

3. The user interacts with the spreadsheet by clicking choices or entering data using the graphical interface that comes with the spreadsheet. Choices can be selected from the box labeled **List Inputs** on either of two worksheets:

   a) **LCC (Sample Calc)** or,
   b) **LCC (Simulations)**.

   A change in either input sheet also changes the other. In the box titled **List Inputs** select choices from the selection boxes for (1) energy price projection, (2) start year, (3) base case design, (4) standard case design, (5) manufacturer cost data (ARI or Rev Eng), and (6) system type (split or single package). A new discount rate or lifetime can also be entered if a value other than the default value or default distribution is wanted, however, this would change the code and we do not recommend saving the spreadsheet after the code is changed.

4. To change assumptions on **List Inputs** click on the assumption you wish to change, and click on the new assumption from the menu.

5. This spreadsheet gives the user two methods of running the spreadsheet.

   a) If the **LCC (Sample Calc)** sheet is chosen, then all calculations are performed for single input values, usually an average. The new results are shown on the same sheet as soon as the new values are entered.

   b) Alternately, if the **LCC (Simulations)** sheet is used, the spreadsheet generates results that are distributions. Some of the inputs are also distributions. The results from the LCC distribution are shown as single values and refer only to the results from the last Monte Carlo sample and are therefore not meaningful. To run the distribution version of the spreadsheet the Excel add-in software called *Crystal Ball* must be enabled.

What is the LCC (Sample Calc) sheet used for?

LCC difference and Payback as provided in the **LCC (Sample Calc)** sheet are based on single-point values. This page can be used to see the effect of changing a single parameter.

How does the user run the *Crystal Ball* simulation? (LCC Simulations sheet)

To produce sensitivity results using *Crystal Ball*, you need simply select ***Run*** from the **Run** menu (on the menu bar). To make basic changes in the run sequence, including altering the number of trials, select ***Run Preferences*** from the **Run** menu. After each simulation run, the user needs to select ***Reset*** (also from the **Run** menu) before ***Run*** can be selected again. Once *Crystal Ball* has completed its run sequence it will produce a series of distributions. Using the menu bars on the distribution results it is possible to obtain further statistical information. The time taken to complete a run sequence can be reduced by minimizing the *Crystal Ball* window in Excel.

A step by step summary of the procedure, for running a distribution analysis, is outlined below:

1. Find the *Crystal Ball* toolbar (at top of screen)
2. Click on *RUN*
3. Select *Preference* and choose from the following choices:
    a) *Monte Carlo*[1]
    b) Latin Hypercube (recommended)
    c) Initial seed choices and whether you want it to be constant between runs
    d) Select number of Monte Carlo **Trials** (we suggest 10,000).

4. To run the simulation, follow the following sequence (on the *Crystal Ball* toolbar)
    RUN
    RESET
    RUN

5. Now wait until the program informs you that the simulation is completed.

What kind of output does *Crystal Ball* generate?

1. After the simulation has finished, to see the distribution charts generated, click on the Windows tab bar that is labeled *Crystal Ball*.

[1]Because of the nature of the program, there is some variation in results due to random sampling when Monte Carlo or Latin Hypercube sampling is used.

2. The life-cycle cost savings and payback periods are defined as **Forecast** cells. The *frequency* charts display the results of the simulations, or trials, performed by *Crystal Ball*. Click on any chart to bring it into view. The charts show the low and high endpoints of the forecasts. The **View** selection on the *Crystal Ball* toolbar can be used to specify whether you want cumulative or frequency plots shown.

3. To calculate the probability of that LCC savings will occur, either type 0 in the box by the right arrow, or move the arrow key with the cursor to 0 on the scale. The value in the **Certainty** box shows the likelihood that the LCC savings will occur. To calculate the certainty of payback period being below a certain number of years, choose that value as the high endpoint.

4. To generate a printout report, select **Create Report** from the **Run** menu. The toolbar choice of **Forecast Windows** allows you to select the charts and statistics you are interested in. For further information on *Crystal Ball* outputs, please refer to *Understanding the Forecast Chart* in the *Crystal Ball* manual.